REMARKS

In view of the above amendments and the following remarks, reconsideration of the objections and rejections set forth in the Office Action of April 29, 2008 is respectfully requested.

In the outstanding Office Action, the Examiner objected to the specification as apparently not containing the correct headings. In order to address these objections while also making various editorial corrections, the entire specification and abstract have now been reviewed and revised. As the revisions are quite extensive, the amendments to the specification and abstract have been incorporated into the attached substitute specification and abstract. For the Examiner's benefit, a marked-up copy of the specification indicating the changes made thereto is also enclosed. No new matter has been added by the revisions. Entry of the substitute specification is thus respectfully requested. In view of the above, it is respectfully submitted that the Examiner's objections to the specification have been overcome.

The Examiner rejected all of original claims 1-12 as being unpatentable over the Toshio reference (JP 03-216223) in view of the Ishii reference (JP 9-57696). However, all of the original claims have now been cancelled and replaced with new claims 13-30, including new independent claims 13 and 24. For the reasons discussed below, it is respectfully submitted that the new claims are clearly patentable over the prior art of record.

As explained in paragraph [0005] on page 2 of the specification, a device including a tool directly mounted to an ultrasonic vibrator is known. However, because the tool is directly mounted, or directly connected, to the ultrasonic vibrator, continuous vibrations applied by the ultrasonic vibrator are too fast compared to the moving speed of the tool. As a result, undesirable vibration, such as vibration waves in the transverse direction with respect to the desired direction of movement of the tool, will be applied to the tool. These transverse vibration waves will cause the tool to move in a transverse direction with respect to the desired direction of movement. Consequently, inaccurate machining will be achieved. For example, the tool will come into contact with the side wall of a bored hole, thereby damaging the surface of the side wall of the hole. The present invention has been developed in order to address this problem.

A discussion of the features of the present invention as recited in the new claims will now be provided below with reference to various portions of the present application. However, reference to any particular portions of the specification or drawings is provided only for illustrative purposes, and is not intended to otherwise limit the scope of the claims to any particular embodiments.

As generally illustrated in Figure 1, the boring device of new independent claim 13 comprises a boring tool 2, a guide 3 for restricting a moving direction of the boring tool 2, a vibrator 1 for applying ultrasonic vibrations to the boring tool 2 to make the boring tool jump, and a float retention member 4 for retaining the boring tool 2 in a floating state at a specified position, and for generating a restoration force to return the boring tool 2 at least to a position where the boring tool 2 contacts the vibrator 1 when the boring tool 2 is displaced from the specified position. As explained in paragraph [0018] of the original specification, and generally illustrated in Figures 2A-2F, the vibrator 1 and the boring tool 2 are *discrete members unattached to each other* such that the boring tool 2 jumps and *separates from the vibrator 1* when the vibrator 1 applies the ultrasonic vibrations to the boring tool 2 (see also paragraph [0009] on page 3; and paragraph [0026] on page 9 of the original specification). As a result of the unattached arrangement between the vibrator and the boring tool to allow the boring tool to jump and separate from the vibrator, the boring tool 2 will not swing or move in a transverse direction with respect to the intended and desired direction of movement for the boring tool 2. Thus, high accuracy boring can be achieved by the boring device of new independent claim 13, without causing any damage to the object to be bored or the boring tool itself (see paragraph [0028] on page 10 of the original specification).

The Toshio reference discloses a press punching method in which a vibrating device (f) is set on a punch (a), and a plumb (g) is set on the vibrating device (f). In particular, the punch (a), the vibrating device (f), and the plumb (g) are designed and arranged *to contact each other constantly*. In particular, the press punching method of the Toshio reference requires that a normal punching force and a vibration accelerating force are *synthesized* for punching. Moreover, the Toshio reference teaches that a synthetic force including the punching force

developed by punch (a), the vibration accelerating force provided by vibrating device (f), and the static load applied by the plumb (g) is applied to the blank (d) during the press punching operation (see left column of page 3 of the Toshio reference with respect to Figure 1b). In order to synthesize (i.e., generate) the synthetic force, the plumb (g), the vibrating device (f), and the punch (a) must move in unison as a single integrated unit, rather than as discrete members unattached to each other which move separately. Thus, it is submitted that the Toshio reference does not teach or even suggest a vibrator and a boring tool being discrete members unattached to each other such that the boring tool jumps and separates from the vibrator when the vibrator applies the ultrasonic vibrations to the boring tool, as required in new independent claim 13.

The Ishii reference teaches a similar arrangement in which a punch (boring tool), a resonator, and a vibrator are fixed to each other. In particular, the ultrasonic punching device of the Ishii reference includes a resonator with a punch on its lower end, and the resonator is connected to an output end of a vibrator which generates ultrasonic vibrations. However, the Ishii reference also does not teach or even suggest a vibrator and a boring tool being discrete members unattached to each other such that the boring tool jumps and separates from the vibrator when the vibrator applies ultrasonic vibrations to the boring tool. Therefore, because neither the Toshio reference nor the Ishii reference teaches a vibrator and a boring tool arranged as required in new independent claim 13, the combination of references would provide no apparent reason for one of ordinary skill in the art to obtain the boring device as recited in new independent claim 13.

Moreover, it is submitted that the Toshio reference cannot even be combined with the Ishii reference. In this regard, the Examiner acknowledged that the Toshio reference does not teach applying *ultrasonic* vibrations to a boring tool. Thus, the Examiner applied the Ishii reference as teaching such a feature. However, it is known that in punching devices such as those used in the Toshio reference, if the frequency of vibration is as low as several hundred Hz, then the tools including the punch and the die will be vibrated sympathetically, causing damage to the tools. Therefore, the Toshio reference teaches that the preferred frequency is set in a relatively low range from several Hz to about 100 Hz (see right column of page 2, lines 25-31).

This preferred range clearly excludes any possible use of ultrasonic vibration in which high frequencies such as 20,000 Hz or greater are employed. In other words, the Toshio reference actually *teaches away* from using ultrasonic vibrations. Therefore, it is submitted that the Toshio reference cannot even be combined with the teachings of the Ishii reference in the manner suggested by the Examiner.

As explained above, the combination of the Toshio reference and the Ishii reference does not teach or even suggest all of the features recited in new independent claim 13, including the arrangement of the vibrator and the boring tool. Moreover, the Toshio reference teaches away from applying ultrasonic vibrations such as those taught in the Ishii reference. Therefore, the Toshio reference cannot be combined with the Ishii reference as suggested by the Examiner. Consequently, it is respectfully submitted that the combination of the Toshio reference and the Ishii reference does not render independent claim 13 unpatentable. Moreover, it is respectfully submitted that new independent claim 13 and the claims that depend therefrom are clearly patentable over the prior art of record.

New independent claim 24 is directed to a boring method of boring an object, comprising retaining a boring tool in a floating state at a specified position, applying ultrasonic vibrations to the boring tool using a vibrator to displace the boring tool, making the boring tool strike the object to be bored, and returning the boring tool having been displaced from the specified position. In addition, the vibrator and the boring tool are *discrete members unattached to each other* such that the boring tool jumps and separates from the vibrator during said applying of the vibrations to the boring tool by the vibrator. Thus, the boring method of new independent claim 24 provides the same advantages as discussed above with respect to new independent claim 13.

As also discussed above with respect to new independent claim 13, the combination of the Toshio reference and the Ishii reference does not teach or even suggest a vibrator and a boring tool being discrete members unattached to each other such that the boring tool separates from the vibrator when the vibrator applies ultrasonic vibrations to the boring tool. Furthermore, because the Toshio reference *teaches away* from the use of *ultrasonic* vibrations, it is submitted

that the Toshio reference cannot be combined with the Ishii reference in the manner suggested by the Examiner. Therefore, for these reason, it is respectfully submitted that new independent claim 24 and the claims that depend therefrom are clearly patentable over the prior art of record.

In view of the above amendments and remarks, it is submitted that the present application is now in condition for allowance. However, if the Examiner should have any comments or suggestions to help speed the prosecution of this application, the Examiner is requested to contact the Applicant's undersigned representative.

Respectfully submitted,

Teruie TAKEMASU et al.

By: _____

W. Douglas Hahm
Registration No. 44,142
Attorney for Applicants

WDH/akl
Washington, D.C. 20006-1021
Telephone (202) 721-8200
Facsimile (202) 721-8250
August 20, 2008

Version with Markings to Show Changes Made

DESCRIPTION

BORING DEVICE AND BORING METHOD

BACKGROUND OF THE INVENTION

TECHNICAL FIELD

[0001]

The present invention relates to a boring device that uses vibrations, such as ultrasonic waves, to bore into an object to be bored, as well as a boring method.

BACKGROUND ART

[0002]

Conventionally, boring into an object to be bored has been performed by press work or electrical discharge. There are problems, however, with press work having poor hole accuracy and electrical discharge having high costs. In view of these problems, ultrasonic machining that uses ultrasonic vibrations is known as a method that can perform boring operations with high accuracy and low costs.

[0003]

As described in Patent Document 1, when using ultrasonic vibration to bore, a tool is directly mounted to an ultrasonic vibrator unit and the boring is performed while continuously applying ultrasonic vibrations to the tool. Patent Reference 1 further discloses the ability to perform ultrasonic machining on holes with very small diameters by mounting a tool with good vertical accuracy to an ultrasonic vibrator unit.

[0004]

Patent Document 1: Unexamined Japanese Patent Publication No. Hei 7-136818

~~DISCLOSURE OF THE INVENTION~~

~~PROBLEMS TO BE SOLVED BY THE INVENTION~~

[0005]

Even though the tool directly mounted to the ultrasonic vibrator as described in Patent Document 1 applies longitudinal ultrasonic vibration waves in the moving direction of the tool, the vibrations continuously being input are too fast compared to the moving speed of the tool. Because of this, transverse vibration waves are inevitably input to the tool. Consequently, the tool that receives these transverse vibration waves moves and comes into contact with the sidewall of the bored hole, damaging the surface of the sidewall of the hole.

[0006]

An object of the present invention is to provide a boring device and a boring method that can perform high accuracy boring.

~~MEANS TO SOLVE THE PROBLEMS~~SUMMARY OF THE INVENTION

[0007]

A boring device of the present invention comprises: a boring tool; a guide for restricting a moving direction of this boring tool; a vibrator for applying vibrations to the boring tool to make the boring tool jump; and a float retention member for retaining the boring tool in a floating state at a specified position and for generating a restoration force to return the boring tool at least up to a position where it comes into contact with the vibrator when the boring tool is displaced from the specified position. It should be appreciated that the boring performed in the present invention includes not only a through hole formed by a punching process but also a blind hole with a bottom formed by an extrusion process.

[0008]

As the vibrator, an ultrasonic horn that converges ultrasonic waves generated by an ultrasonic vibrator and generates ultrasonic vibrations from the tip thereof, a piezoelectric actuator that utilizes inertial force accompanied by rapid deformations of a piezoelectric device or an electrostrictive device to generate very small vibrations, a device that applies repeated impacts by means of an indirect impact tool such as a so-called hammer punch in which a hammer strikes a punch to transfer the impact force of the hammer through the punch utilizing the inertia, and the like can be used.

[0009]

According to the boring device of the present invention, the boring tool retained in a floating state at a specified position is made to jump by applying a vibration from the vibrator, separate from the ~~vibrator~~boring tool, and strike the object to be bored while the moving direction is restricted by the guide. Since the boring tool is separated from the vibrator at this time, it vibrates in the moving direction, applying the force of the moving direction to the struck object to be bored and thereby performing the boring operation.

[0010]

The boring tool that strikes the object to be bored is returned at least up to a position where it comes into contact with the vibrator by a restoring force of the float retention member or to the original specified position before the tool jumped, for example, and once again receives vibrations from the vibrator and jumps. In other words, the boring tool repeatedly separates from the vibrator and strikes the object to be bored, thereby repeatedly boring the object to be bored.

[0011]

~~Hereupon, the~~The boring device of the present invention is preferably equipped with a pressing device that presses the vibrator towards the boring tool. In this case, because the vibrator applies vibrations while the tool is pressed towards the object to be bored and then

jumps towards the object, the boring tool has a small throw up (movement) to the object to be bored. Consequently, the boring tool gradually bores the object to be bored while moving back and forth between the vibrator and the object to be bored with an amplitude smaller than the former case.

~~ADVANTAGE OF THE INVENTION~~

[0012]

According to the present invention, the boring tool is retained in a floating state at a specified position inside the guide that restricts the moving direction thereof, the vibrator applies vibrations to the boring tool to make the boring tool jump towards the object to be bored and then ~~make~~ makes the boring tool strike the object to be bored, and the boring tool displaced from the specified position is returned at least up to a position where the boring tool comes into contact with the vibrator. This makes it possible to perform a boring operation using the boring tool applying vibrations to the object to be bored in the moving direction. Because of this, shifting outside the moving direction of this boring tool can be prevented and a highly accurate boring operation can be obtained.

[0013]

In addition, making the boring tool jump while being pressed towards the object to be bored reduces the throw (movement) of the boring tool up to the object to be bored ~~and the~~. The boring tool gradually bores the object to be bored while moving back and forth between the vibrator and the object to be bored at a small amplitude, thereby reducing the impact force applied to the tip of the boring tool. This makes it possible to extend the life of the boring tool.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

[Fig. 1] is an outlined cross section illustrating the boring device in one embodiment of the present invention.

[Fig. 2A] illustrates the boring process using the boring device of Fig. 1.

[Fig. 2B] illustrates the boring process using the boring device of Fig. 1.

[Fig. 2C] illustrates the boring process using the boring device of Fig. 1.

[Fig. 2D] illustrates the boring process using the boring device of Fig. 1.

[Fig. 2E] illustrates the boring process using the boring device of Fig. 1.

[Fig. 2F] illustrates the boring process using the boring device of Fig. 1.

[Fig. 3A] is an enlarged view of the contact area between a punch and a work; the figure also illustrates the boring process when forming a blind hole with a bottom.

[Fig. 3B] is an enlarged view of the contact area between a punch and a work; the figure also illustrates the boring process when forming a blind hole with a bottom.

[Fig. 4A] illustrates the boring process accompanied by a pressing action using a pressing device.

[Fig. 4B] illustrates the boring process accompanied by a pressing action using the pressing device.

[Fig. 4C] illustrates the boring process accompanied by a pressing action using the pressing device.

[Fig. 4D] illustrates the boring process accompanied by a pressing action using the pressing device.

[Fig. 4E] illustrates the boring process accompanied by a pressing action using the pressing device.

[Fig. 4F] illustrates the boring process accompanied by a pressing action using the

pressing device.

DESCRIPTION OF THE REFERENCE NUMERALS

[0015]

1: ultrasonic hone

2: punch

2a: head

2b: processing portion

2c: body shank

3: guide bush

3a, 3b: guide hole

4: elastic body

5: die

5a: boring hole

6: pressing device

~~BEST MODE FOR CARRYING OUT~~DETAILED DESCRIPTION OF THE INVENTION

[0016]

Fig. 1 is an outlined cross section illustrating the boring device in one embodiment of the present invention, and Figs. 2A to F show the boring process using the boring device of Fig. 1.

[0017]

As shown in Fig. 1, the boring device in this embodiment comprises: ~~a~~ an ultrasonic horn 1 that functions as a vibrator; a punch 2 that functions as a boring tool that bores a ~~work~~ workpiece W which is an object to be bored; a guide bush 3 that guides the punch 2 in a

moving direction; an elastic body 4 that functions as a float retention member to retain the punch 2 in a floating state on the guide bush 3; a die 5 that functions as a boring tool formed in pairs with the punch 2; and a pressing device 6 that presses the ultrasonic horn 1 towards the die 5 or the ~~work~~ workpiece W.

[0018]

The ultrasonic horn 1 converges ultrasonic waves generated by an ultrasonic vibrator (not shown) and generates ultrasonic vibrations from a tip thereof. The ultrasonic horn 1 and the punch 2 are not fixed. Because of this, when vibrations are applied to a back end (a head 2a) of the punch 2 by the ultrasonic horn 1, the punch 2 jumps and moves separating from the ultrasonic horn 1.

[0019]

The punch 2 has the head 2a ~~whereon~~ on which vibrations are applied by the ultrasonic horn 1, a processing portion 2b that comes into contact with the ~~work~~ workpiece W to perform the boring, and a body shank 2c that connects the head 2a and the processing portion 2b. The punch 2 is retained in a floating state at a specified position (position shown in Fig. 2A) by the elastic body 4 provided between the head 2a and the guide bush 3.

[0020]

The area where the head 2a of the punch 2 comes into contact with the ultrasonic horn 1 has an arc (i.e., spherical) surface as shown in Fig. 1. If both of the ultrasonic horn 1 and the punch 2 coming into contact with each other have flat surfaces and if either of the surfaces is slightly sloped (i.e., either the horn 1 or the punch 2 is slightly inclined), partial contact will occur and it will become difficult for the punch 2 to strike downward in a straight direction. In contrast to this, if the head 2a of the punch 2 has an arc surface or more preferably a spherical surface, the head 2a of the punch 2 and the ultrasonic horn 1 always come into contact at a point close to the center axis of the punch 2 and it becomes easier for

the punch 2 to strike downward in a straight direction. The shape of the cross section of the tip of the processing portion 2b of the punch 2 can be any shape such as a circular shape, a blade shape, a square shape, a triangle shape, or an oval shape.

[0021]

The elastic body 4 has a restoration force that returns at least to a position where contact is made with the ultrasonic horn 1 and, as an example, to the specified position shown in Fig. 2A. This restoration force returns the punch 2 that has been displaced from the specified position to the specified position. The elastic body 4 comprises a spring (plate spring, coil spring, spiral spring, air spring, or rubber), a damper, or a combination of these for example.

[0022]

The die 5 holds the workpiece W along with the punch 2. In addition, the die 5 has a boring hole 5a that corresponds to the processing portion 2b of the punch 2 and a tapered hole 5b communicating with the boring hole 5a. The tapered hole 5b expands in a boring direction, that is, in a direction from an area connected to the boring hole 5a towards a lower side (open side) of the die 5. This tapered hole 5b easily discharges punch scraps generated after the processing downward and makes it difficult for the punch scraps to clog the hole.

[0023]

The guide bush 3, in order to restrict the moving direction of the punch 2, has a cylindrical guide hole 3a inside of which the head 2a of the punch 2 slides and a cylindrical guide hole 3b inside of which the processing portion 2b of the punch 2 slides. The operation of the body shank 2c of the punch 2 is restricted to only in an axial direction using these guide holes 3a and 3b. The elastic body 4 described above is arranged between a lower end of the guide hole 3a and the head 2a of the punch 2.

[0024]

The head 2a of the punch 2, the body shank 2c, the processing portion 2b, and the guide holes 3a and 3b of the guide bush 3 are formed in a stepped shape with the diameter becoming smaller towards the boring direction of the punch 2. The purpose of this shape is to adjust the mating at the head 2a of the punch 2 with the largest diameter and the guide hole 3a as well as to provide play in the processing portion 2b and the guide hole 3b. The reason for providing play in the processing portion 2b and the guide hole 3b is to prevent the tip of the processing portion 2b from ~~damaging~~ being damaged due to deformation such as bending or buckling caused by excessive stress received.

[0025]

The elastic body 4 is also retained so as to be held between the stepped portion between the head 2a and the body shank 2c of the punch 2 and the stepped portion of the guide holes 3a and 3b. This type of retained state makes it possible to retain the punch 2 in a floating state by the simplest structure. Although not shown in the ~~figure~~figures, the punch 2 can be retained in a floating state by providing an elastic body on the outside of the guide holes 3a and 3b.

[0026]

In a plastic processing device having the structure described above, when the ultrasonic horn 1 generating ultrasonic vibration waves is brought into contact with the head 2a of the punch 2 as shown in Fig. 2A, ultrasonic vibration waves from the ultrasonic horn 1 are applied to the punch 2 and the punch 2 separates from the ultrasonic horn 1 jumping towards the ~~work~~ workpiece W. At this time the operation of the head 2a and the processing portion 2b of the punch 2 is restricted to only in the axial direction by the guide holes 3a and 3b of the guide bush 3. Accordingly, the punch 2 moves straight towards the ~~work~~ workpiece W without swinging from side to side and then arrives at the ~~work~~ workpiece W.

[0027]

Thereafter, as shown in Fig. 2B, the restoration force of the elastic body 4 makes the punch 2 jump towards the ultrasonic horn 1 and then as shown in Fig. 2C, return to the initial position of the punch 2. Further, the punch 2 receives an application of ultrasonic vibration waves from the ultrasonic horn 1 once again and jumps towards the ~~work~~ workpiece W. When the punch 2 arrives at the ~~work~~ workpiece w as shown in Fig. 2D, the restoration force of the elastic body 4 once again makes the punch 2 jump towards the ultrasonic horn 1 and be returned.

[0028]

In this manner the punch 2 is repeatedly separated from the ultrasonic horn 1 and strikes the ~~work~~ workpiece W (refer to Figs. 2D and 2E). Thus, the ~~work~~ workpiece W undergoes high accuracy boring by the repetitive force received from the punch 2 (refer to Fig. 2F).

[0029]

In the above-mentioned embodiment, ~~whereas as~~ an example of forming a through hole by a punching process was described as an example of a boring process~~,~~. However, a blind hole with a bottom can also be formed by an extrusion process using this boring device. Fig. 3A and Fig. 3B are enlarged views of the contact area between the punch 2 and the ~~work~~ workpiece W and illustrate the boring process when forming a blind hole with a bottom.

[0030]

In like manner to above, the operation to apply vibrations using the ultrasonic horn 1 and to make the processing portion 2b of the punch 2 (that jumped) repeatedly strike the ~~work~~ workpiece W as shown in Fig. 3A repeats and the ~~work~~ workpiece W is extruded towards the boring hole 5a of the die 5 as shown in Fig. 3B. The blind hole C provided with the bottom B is formed by this operation.

[0031]

In the above-mentioned embodiment, ~~whereas~~ an example was described in which the boring process was performed with the position of the ultrasonic horn 1 fixed and the pressing device 6 not driven during the boring process~~,~~. However, the process can also be performed while pressing the ultrasonic horn 1 towards the ~~work~~ workpiece W using this pressing device 6 during the boring process.

[0032]

Figs. 4 A to F illustrate the boring process accompanied by a pressing action using the pressing device 6.

In this case, at first, the ultrasonic horn 1 and the punch 2 are statically pressed by the pressing device 6 until the tip of the body shank 2c of the punch 2 comes into contact with the upper surface of the ~~work~~ workpiece W as shown in Fig. 4A and Fig. 4B. Next, the ultrasonic horn 1 applies ultrasonic vibration waves to the punch 2 while the pressing device 6 is pressing (refer to Fig. 4C).

[0033]

At this time, the punch 2 separates from the ultrasonic horn 1, jumps (is pushed) towards the ~~work~~ workpiece W, jumps back to the ultrasonic horn 1 by the restoration force of the elastic body 4, and then comes into contact with the ultrasonic horn 1. The punch 2 repeats this operation to perform high accuracy boring on the ~~work~~ workpiece W (refer to Fig. 4D, Fig. 4E, and Fig. 4F). Since the punch 2 jumps while being pressed towards the ~~work~~ workpiece W by the pressing device 6, the distance up to the ~~work~~ workpiece W is short.

[0034]

Consequently, the punch 2 gradually bores the work W at a small amplitude while moving back and forth between the ultrasonic horn 1 and the ~~work~~workpiece W. Since this reduces the impact force applied to the tip of the punch 2, the life of the punch 2 can be extended. When the ~~work~~workpiece W is made of a fibrous material, a thick material, or a

composite material, it is preferable to perform the process while the pressing device 6 presses the ultrasonic horn 1 towards the ~~work~~workpiece W.

[0035]

The pressing speed of the pressing device 6 is approximately the plate thickness (mm) x 0.05 - the plate thickness (mm) x 5 (/second). In other words, when the plate thickness is 1 mm, the speed is most preferably 0.05 to 5 mm/second. The ultrasonic frequency is approximately 20 to 80 kHz and the optimum ultrasonic frequency is 40 kHz. Although the ultrasonic wave output will greatly change depending on the material of the ~~work~~workpiece W, the optimum output is approximately 50 to 1000 W. For example, the output is approximately 500 to 800W with a 0.5 to 1.0 mm thick steel plate and approximately 200 to 400W with a 0.1 mm thick foil.

INDUSTRIAL APPLICABILITY

[0036]

The present invention is useful as a device and a method to bore an object to be bored utilizing vibrations such as ultrasonic waves. In particular, the present invention is suitable for high accuracy boring processes.

ABSTRACT

A boring such as a high accuracy boring is performed by inputting vibration only in the moving direction of a tool. The device ~~comprises~~ includes an ultrasonic horn ~~(1)~~ functioning as a vibrator, a punch ~~(2)~~ functioning as a boring tool for boring into a ~~work~~workpiece ~~(W)~~ which is an object to be bored, a guide bush ~~(3)~~ guiding the punch ~~(2)~~ in the moving direction, an elastic body ~~(4)~~ for retaining the punch ~~(2)~~ in a floating state on the guide bush ~~(3)~~, and a die ~~(5)~~ functioning as the boring tool formed in pairs with the punch ~~(2)~~. The punch ~~(2)~~ is floatingly retained by the elastic body ~~(4)~~ inside the guide bush ~~(5)~~, and vibration is applied to the punch ~~(2)~~ by the ultrasonic horn ~~(1)~~ to make the punch ~~(2)~~ jump toward the ~~work~~workpiece ~~(W)~~ to strike the ~~work~~workpiece ~~(W)~~ for boring into the ~~work~~workpiece ~~(W)~~.